CHAPTER 03300 HYDRAULICS AND HYDRAULIC STRUCTURES

SECTION 03301 INTRODUCTION

This chapter provides policies and technical procedures for analyzing the majority of stormwater facilities required for land alteration projects. However, more detailed analyses may be required depending on the specific site characteristics. Also, a set of Standard Details are available through WPWD or on the City of Westfield's website at www.westfield.in.gov that provides guidance on the design of various hydraulic structures that may not have been covered in this chapter. Adherence to the noted standard details shall be required in addition to other requirements in this chapter. In case of discrepancy, the most restrictive requirement shall apply.

03301.01 Abbreviations and Definitions

Abbreviations

BMP: Best Management Practice

COE: United States Army Corps of Engineers

IDEM: Indiana Department of Environmental Management

IDNR: Indiana Department of Natural Resources

INDOT: Indiana Department of Transportation

NRCS: USDA-Natural Resources Conservation Service (formerly SCS)

USDA: United States Department of Agriculture

Definitions

Antecedent Moisture Condition: The index of runoff potential before a storm event. The index, developed by the Natural Resource Conservation Service (NRCS), is an attempt to account for the variation of the NRCS runoff curve number (CN) from storm to storm.

Catch Basin: A chamber usually built at the curb line of a street for the admission of surface water to a storm drain or subdrain, having at its base a sediment sump designed to retain grit and detritus below the point of overflow.

Channel:	A portion of a natural or artificial watercourse which periodically or continuously contains moving water, or which forms a connecting link between two bodies of water. It has a defined bed and banks which serve to confine the water.
Culvert:	A closed conduit used for the conveyance of surface drainage water under a roadway, railroad, canal or other impediment.
Curve Number:	The NRCS index that represents the combined hydrologic effect of soil, land use, land cover, hydrologic condition and antecedent runoff condition.
Depression Storage:	Non-riverine depressions in the earth where stormwater collects. The volumes are often referred to in units of acre-feet.
Design Storm:	A selected storm event, described in terms of the probability of occurring once within a given number of years, for which drainage or flood control improvements are designed and built.
Drainage Area:	The area draining into a stream at a given point. It may be of different sizes for surface runoff, subsurface flow and base flow, but generally the surface runoff area is considered as the drainage area.
Dry-bottom Detention Basin:	A basin designed to be completely dewatered after having provided its planned detention of runoff during a storm event.
Duration:	The time period of a rainfall event.
Hydrograph:	For a given point on a stream, drainage basin, or a lake, a graph showing either the discharge, stage (depth), velocity, or volume of water with respect to time.
Infiltration:	Passage or movement of water into the soil.
Inlet:	An opening into a storm drain system for the entrance of surface storm water runoff, more completely described as a storm drain inlet.
Lowest Adjacent Grade:	The elevation of the lowest grade adjacent to a structure, where the soil meets the foundation around the outside of the structure (including structural members such as basement walkout, patios, decks, porches, support posts or piers, and rim of the window well).
Major Drainage System:	Drainage system carrying runoff from an area of one or more square miles.

Minor Drainage System:	Drainage system carrying runoff from an area of less than one square mile.
Peak Discharge:	The maximum instantaneous flow from a given storm condition at a specific location.
Rainfall Intensity:	The rate at which rain is falling at any given instant, usually expressed in inches per hour.
Regulated Drain:	A drain subject to the provisions of the Indiana Drainage Code, I.C.-36-9-27.
Runoff:	That portion of precipitation that flows from a drainage area on the land surface, in open channels, or in stormwater conveyance systems.
Storm Frequency:	The time interval between major storms of predetermined intensity and volumes of runoff (e.g. a 5-yr., 10-yr., or 20-yr. storm).
Storm Sewer:	A closed conduit for conveying collected storm water, while excluding sewage and industrial wastes. Also called a storm drain.
Stormwater Drainage System:	All means, natural or man-made, used for conducting storm water to, through or from a drainage area to any of the following: conduits and appurtenant features, canals, channels, ditches, storage facilities, swales, streams, culverts, streets and pumping stations.
Stormwater Facility:	All ditches, channels, conduits, levees, ponds, natural and manmade impoundments, wetlands, tiles, swales, sewers and other natural or artificial means of draining surface and subsurface water from land.
Swale:	An elongated depression in the land surface that is at least seasonally wet, is usually heavily vegetated, and is normally without flowing water. Swales conduct stormwater into primary drainage channels and may provide some groundwater recharge.
Storage:	Any structural BMP intended to store or detain stormwater and slowly release it to receiving waters or drainage systems. The term includes detention and retention basins.
Tailwater:	The water surface elevation at the downstream side of a hydraulic structure (i.e. culvert, bridge, weir, dam, etc.).

Time of Concentration:	The travel time of a particle of water from the most hydraulically remote point in the contributing area to the point under study. This can be considered the sum of an overland flow time and times of travel in street gutters, storm sewers, drainage channels, and all other drainage ways.
Watercourse:	Any river, stream, creek, brook, branch, natural or man-made drainageway in or into which stormwater runoff or floodwaters flow either continuously or intermittently.
Watershed:	The region drained by or contributing water to a specific point that could be along a stream, lake or other stormwater facilities. Watersheds are often broken down into subareas for the purpose of hydrologic modeling.
Wet-bottom Detention Basin:	Also referred to as a "Retention Basin", is a basin designed to retain a permanent pool of water after having provided its planned detention of runoff during a storm event.

To provide consistency within this chapter the following symbols will be used. These symbols were selected because of their wide use in hydrologic and hydraulic publications. In some cases the same symbol is used in existing publications for more than one definition. Where this occurs in this chapter, the symbol will be defined where it occurs in the text or equations.

TABLE 03301:1: Symbols and Definitions

Symbols	Definition	Units
A	Drainage area	acres
C	Runoff Coefficient	-
CN	NRCS-runoff curve number	-
D	Duration	hours
I	Rainfall intensity	in/hr
N	Manning roughness coefficient	-
Q	Rate of runoff	cfs
q_p	Peak rate of discharge	cfs
tc or Tc	Time of concentration	min
V	Velocity	ft/s

SECTION 03302 STORMWATER DETENTION DESIGN FOR PEAK FLOW CONTROL

The following shall govern the design of any improvement with respect to the detention of stormwater runoff for peak flow control. Basins shall be constructed to temporarily detain the stormwater runoff that exceeds the maximum peak release rate authorized by the Ordinance and these Technical standards. The required volume of storage provided in these basins, together with such storage as may be authorized in other on-site facilities, shall be sufficient to control excess runoff from the 10-year or 100-year storm as explained below in Sections 03302.02 and 03302.03. Also, basins shall be constructed to provide adequate capacity to allow for sediment accumulation resulting from development and to permit the pond to function for reasonable periods between cleanings.

In addition to the requirement for peak flow control through detention, the Stormwater Management Ordinance and Technical Standards require the developer to address Channel Protection and Water Quality Control requirements discussed in Chapter 03700. The proper way to accommodate the water quality, channel protection, and peak flow rate control of a site is to first consider addressing the water quality and channel protection volume requirements through conventional or LID approaches (as described in Chapter 03700) and then add in the required detention storage for peak flow rate control to the overall site design. Meeting the channel protection/water quality volume requirements, either using Conventional or LID Approaches, often include providing extended detention storage features that are usually combined with the detention storage needed for peak runoff rate control of the site into one facility. The following is the required calculation sequence for designing a detention pond with a combined extended detention and peak flow control detention functions. These steps should be followed carefully to avoid potential future rework.

1. Calculate the required extended detention storage volume as needed to address the Channel Protection Volume (CPv) through the methodology provided in Chapter 03700 (depending on the approach utilized, there may be no need for providing an extended detention storage).

2. Determine the control elevation/invert for the drain serving the proposed extended detention storage (ensuring a positive drain to the site outlet). This will be the elevation of the bottom of the proposed extended detention storage and top of the permanent pool if a wet bottom pond is being provided for.

3. Design a storage space to accommodate the extended detention storage volume determined in Step 1, assuming 0.0 cfs going through the drain that will serve this extended detention storage volume. The top of this storage space will be the bottom of the peak flow rate control detention storage and the invert of the main outlet of this peak flow rate control detention storage.

4. Design the main outlet of the peak flow rate control detention storage, sized to carry the allowable 10-year and 100-year release rates, with its control elevation/invert at the top of the extended detention storage space. For storage space calculation purposes, use the actual orifice size calculated to accommodate the release rates regardless of whether the orifice size is smaller or larger than the minimum orifice size allowed under the Ordinance or Technical Standards.

5. Design the peak flow rate control detention storage space by routing the 10-year and 100-year inflow hydrographs through the pond, assuming the pond is empty to the control elevation of the extended detention storage drain as determined in Step 2, but still assuming 0.0 cfs can get out of the extended detention storage drain as the pond fills up. The resulting maximum water surface elevation is the 100-year pool elevation, where the invert of the emergency overflow weir (sized for 1.25 times the peak inflow rate) is located. The pond size and control elevation/invert elevations are final at this stage.

6. Determine the size of the extended detention storage drain and design the drain system in a manner to meet the extended detention minimum and maximum emptying time requirements discussed in Chapter 03700. Due to typically required clog-free design and maintenance of the extended detention storage

drain structures, the minimum orifice size requirements do not apply to these drain structures.

7. To make sure that the addition of the release through the drain will not cause the allowable release rate to be exceeded, reroute the 10-year and 100-year inflow hydrographs through the pond, this time allowing water to also leave through the extended detention storage drain as the pond fills up. If the total peak outflow discharge exceeds the allowable release rate, reduce the size of the main outlet orifice accordingly (but do not go back to redesign the storage space).

8. If the calculated orifice size of the main peak flow rate control storage outlet is less than the minimum orifice size allowed in the Ordinance or these Technical Standards, designate the minimum orifice size on the construction plans, but do not go back and recalculate/redesign the storage spaces.

03302.01
Acceptable
Detention Facilities

The increased stormwater runoff resulting from a proposed development should be detained on-site by the provisions of appropriate wet bottom or dry bottom detention facilities, parking lots, or other acceptable techniques. Measures that retard the rate of overland flow and the velocity in runoff channels shall also be used to partially control runoff rates.

03302.02
Allowable Release
Rates

General Release Rates

Control devices shall limit the discharge to a rate such that the post-developed release rate from the site is no greater than 0.1 cfs per acre of development for 0 to 10 year return interval storms and 0.3 cfs per acre of developed area for 11 to 100 year return interval storms. The above fixed general release rates may be set at a lower value by the WPWD for certain watersheds if more detailed data becomes available as a result of comprehensive watershed studies conducted and/or formally approved and adopted by the WPWD. The applicant shall confirm the applicable release rates with the WPWD prior to initiating the design calculations to determine whether a basin-specific rate has been established for the watershed.

For sites where the pre-developed area has more than one (1) outlet, the release rate should be computed based on pre-developed discharge to each outlet point. The computed release rate for each outlet point shall not be exceeded at the respective outlet point even if the post developed conditions would involve a different arrangement of outlet points.

Site-Specific Release Rates for Sites with Depressional Storage

For sites where depressional storage exists, the general release rates provided above may have to be further reduced. If depressional storage exists at the site, site-specific release rates must be calculated according to methodology described in Chapter 03200, accounting for the depressional storage by modeling it as a pond whose outlet is a weir at an elevation that stormwater can currently overflow the depressional storage area. Post developed release rate for sites with depressional storage shall be the 2-year pre-developed peak runoff rate for the post-developed 10-year storm and 10-year pre-developed peak runoff rate for the post-developed 100-year storm. In no case shall the calculated site-specific release rates be larger than general release rates provided above.

Note that by definition, the depressional storage does not have a direct gravity outlet but if in agricultural production, it is more than likely drained by a tile and should be modeled as “empty” at the beginning of a storm. The function of any existing depressional storage should be modeled using an event hydrograph model to determine the volume of storage that exists and its effect on the existing site release rate. To prepare such a model, certain information must be obtained, including delineating the tributary drainage area, the stage-storage relationship and discharge-rating curve, and identifying the capacity and elevation of the outlet(s).

The tributary area should be delineated on the best available topographic data. After determining the tributary area, a hydrologic analysis of the watershed should be performed, including, but not limited to, a calculation of the appropriate composite runoff curve number and time of concentration. Stage-storage data for the depressional area should be obtained from the site topography. The outlet should be clearly marked and any calculations performed to create a stage-discharge rating curve must be included with the stormwater submittal.

Also note that for determining the post-developed peak runoff rates, the depressional storage must be assumed to be filled unless the WPWD can be assured, through a dedicated easement, that the noted storage will be preserved in perpetuity.

Downstream Restrictions

In the event the downstream receiving channel or storm sewer system is inadequate to accommodate the post-developed release rate provided above, then the allowable release rate may need to be reduced to that rate permitted by the capacity of the receiving downstream channel or storm sewer system. Additional detention, as determined by the WPWD, may be required to store that portion of the runoff exceeding the capacity of the receiving sewers or waterways. When such downstream restrictions are suspected, WPWD may require additional analysis to determine the receiving system's limiting downstream capacity.

If the proposed development makes up only a portion of the undeveloped watershed upstream of the limiting restriction, the allowable release rate for the development shall be in direct proportion to the ratio of its drainage area to the drainage area of the entire watershed upstream of the restriction.

As an alternative, off-site drainage improvements may be required. Those improvements may include, but are not limited to, extending storm sewers, clearing, dredging, stream bank stabilization, and/or removal of obstructions to open drains or natural water courses, and the removal or replacement of undersized culvert pipes as required by the WPWD.

Regulated Drain Watershed Considerations

If the project site is within a Hamilton County Regulated Drain Watershed, the applicant will also need to abide by the Hamilton County Surveyor's Office applicable detention requirements, whether the site is located in an incorporated area or not.

03302.03 Methodology for Determination of Detention Storage Volume

A. Development Sites Less than or Equal to 5 Acres in Size, With a Contributing Drainage Area Less than or Equal to 50 Acres and No Depressional Storage

The required volume of stormwater storage may be calculated using the Rational Method and based on the runoff from a 100-year return period storm. A computer model, such as TR-55 (NRCS), TR-20 (NRCS), HEC-HMS (COE), and HEC-1 (COE), that can generate hydrographs based on the NRCS TR-55 time of concentration and curve number calculation methodologies may also be used along with a 24-hour duration NRCS Type 2 storm. Note that for the purpose of determining the post-developed conditions curve numbers, due to significant disturbance to the upper soil layers during the construction activities, the initially determined hydrologic soil group for disturbed areas should be changed to the next less infiltrating capacity category (i.e., A to B, B to C, and C to D).

> **LID Exception:** If Low Impact Development (LID) approach is pursued in satisfying the requirements noted in Chapter 03700 (Post-Construction Stormwater Quality Management), the post-developed CN for the protected undisturbed or restored disturbed areas meeting the requirements described in Chapter 03700 and BMP Fact Sheets may be determined based on pre-development underlying soil layer.

The following 9-step procedure, based on the Rational Method, may be used to determine the required volume of storage

<u>Step</u> <u>Procedure</u>

1. Determine total drainage area in acres "A".
2. Determine the parcel area tributary to each outlet and determine the post-development 100-year release runoff rate (Q_u) based on general release rates provided in Chapter 6 of these Technical Standards document.
3 Determine composite runoff coefficient "C_d" based on developed conditions and a 100-year return period.
4. Determine 100-year return rainfall intensity "I_d" for various storm durations "t_d" up through the 24-hour duration using Table 03201-3.
5. Determine developed inflow rates "Q_d" for various storm durations "t_d", measured in hours.

$$Q_d = (C_d)(I_d)(A_d)$$

6. Compute a storage rate "$S(t_d)$" for various storm durations "t_d" up through the 24-hour duration.

$$S(t_d) = (Q_d) - (Q_u)$$

7. Compute required storage volume "S_R" in acre-feet for each storm duration "t_d". This assumes a triangular hydrograph of duration ($2t_d$) hours with a peak flow of $S(t_d)$ at t_d hours.

$$S_R = S(t_d)\left(\frac{t_d}{12}\right)$$

8. Select largest storage volume computed in Step 7 for any storm duration "t_d" for detention basin design.

9. Repeat Steps 2-8 of this process for the post-developed 10-year storm.

B. Development Sites Greater Than 5 Acres in Size or Contributing Drainage Area Greater than 50 Acres or With Significant Depressional Storage

All runoff detention storage calculations for these development sites shall be prepared using a computer model that can generate hydrographs based on the NRCS TR-55 time of concentration and curve number calculation methodologies. Note that for the purpose of determining the post-developed conditions curve numbers, due to significant disturbance to the upper soil layers during the construction activities, the initially determined hydrologic soil group for disturbed areas should be changed to the next less infiltrating capacity category (i.e., A to B, B to C, and C to D).

LID Exception: If Low Impact Development (LID) approach is pursued in satisfying the requirements noted in Chapter 03700 (Post-Construction Stormwater Quality Management), the post-developed CN for the protected undisturbed or restored disturbed areas meeting the requirements described in Chapter 03700 and BMP Fact Sheets may be determined based on pre-development underlying soil layer.

The 24-hour NRCS Type 2 Rainfall Distribution shall be utilized to determine the required storage volume. The allowable release rates shall be determined based on the methodologies provided in Section 03302.02. Examples of computer models that can generate such hydrographs include TR-55 (NRCS), TR-20 (NRCS), HEC-HMS (COE), and HEC-1 (COE). These programs may be downloaded free of charge from the associated agencies' web sites. The computer models ICPR and Pond Pack may also be used. However, the latter computer software are proprietary. If interconnected ponds are utilized, the use of ICPR or Pond Pack may be required to appropriately model the more complex hydrologic and hydraulic relationships associated with such system. Other models may be acceptable and should be accepted by the WPWD prior to their utilization.

03302.04 Management of Off-Site Runoff

Runoff from all upstream tributary areas (off-site land areas) may be bypassed around the detention/retention facility without attenuation. Such runoff may also be routed through the detention/retention facility, provided that a separate, secondary outlet system is incorporated for the safe passage of such flows, i.e., not through the primary outlet of a detention facility. Unless the pond is being designed as a regional detention facility and therefore all off-site runoff to the pond retained, the primary outlet structure shall be sized and the invert elevation of the secondary outlet for bypassing off-site runoff determined according to the on-site runoff only. To accomplish this, the 100-year on-site runoff must be determined by temporarily ignoring the off-site runoff and routed through the pond and through the primary outlet pipe. The resulting pond elevation would be the invert elevation of the secondary outlet. Once the size and location of the primary outlet structure and the invert elevation of the secondary outlet for off-site runoff are determined by considering on-site runoff only, the size of the secondary outlet and the 100-year pond elevation is determined by routing the entire inflow, on-site and off-site, through the pond. Once the 100-year pond elevation is determined in this manner, the crest elevation of the open emergency weir noted in 03302.10 (below) is set at that elevation. Note that the total peak flow released from the outlet system shall not be larger than the total of the allowable release rate and the off-site flow being bypassed through the pond for the 100-year event.

Note that the efficiency of the detention/retention facility in controlling the on-site runoff may be severely affected if the off-site area is considerably larger than the on-site area. As a general guidance, on-line detention may not be effective in controlling on-site runoff where the ratio of off-site area to on-site area is larger than 5:1. Additional detention (above and beyond that required for on-site area) may be required by the WPWD when the ratio of off-site area to on-site area is larger than 5:1.

03302.05 General Detention Basin Design Requirements

1. The detention facility shall be designed in such a manner that a minimum of 90% of the maximum volume of water stored and subsequently released at the design release rate shall not result in a storage duration in excess of 48 hours from the start of the storm unless additional storms occur within the period. In other words, the design shall ensure that a minimum 90% of the original detention capacity is restored within 48 hours from the start of the design 100-year storm (i.e., within 36 hours after pond reaches its full position).

2. The 100-year elevation of storm water detention facilities shall be separated by not less than 25 feet from any building or structure to be occupied. The Lowest Adjacent Grade (including walkout basement floor elevation) for all residential, commercial, or industrial buildings shall be set a minimum of 2 feet above the 100-year pond elevation or 2 feet above the emergency overflow weir elevation, whichever is higher. In addition to the Lowest Adjacent Grade requirements, any basement floor must be at least a foot above the normal water level of any wet-bottom pond. Special considerations, based on detailed geotechnical analysis, should be made prior to considering placement of any basement below the 100-year flood elevation of an adjacent flooding source or pond.

3. No detention facility or other water storage area, permanent or temporary, shall be constructed under or within twenty (20) feet of any pole or high voltage electric line. Likewise, poles or high voltage electric lines shall not be placed within twenty (20) feet of any detention facility or other water storage area.

4. All stormwater detention facilities shall be separated from any road right-of-way (using the most restrictive right-of-way possible) by minimum of 50 feet, measured from the top of bank or the 100-year pool if no defined top of bank is present. Use of guard rails, berms, or other structural measures are required and may be considered in lieu of the above-noted setbacks to minimize the chances of vehicles sliding into the pond with approval from the WPWD.

5. Slopes no steeper than 3 horizontal to 1 vertical (3:1) for safety, erosion control, stability, and ease of maintenance shall be permitted.

6. Debris Guard designed in accordance with the WPWD shall be provided for any pipe or opening that receives water.

7. Outlet control structures shall be designed to operate as simply as possible and shall require little or no maintenance and/or attention for proper operation. For maintenance purposes, the outlet shall be a minimum of 0.5 foot above the normal water level of the receiving water body. They shall limit discharges into existing or planned downstream channels or conduits so as not to exceed the predetermined maximum authorized peak flow rate. If an outlet control structure includes an orifice to restrict the flow rate, such orifice shall be no less than 6 inches in diameter, even if the 6 inch diameter orifice results in a discharge that exceeds the predetermined maximum authorized peak flow release rates as determined using methodologies in Section 03302.02. Potential infiltration of accumulated water into the ground shall not be taken into account as part of the calculations for sizing the basin's outlet structure.

8. Grass or other suitable vegetative cover shall be provided along the banks of the detention storage basin. Vegetative cover around detention facilities should be maintained as provided by restrictive covenants, policy or codes.

9. Debris and trash removal and other necessary maintenance shall be performed as provided by restrictive covenants, policy or codes.

10. No residential lots, or any part thereof, shall be used for any part of a detention basin, assumed full to the 100-year water surface elevation or the emergency overflow weir elevation, whichever is higher. Detention basins, assumed full to the 100-year water surface elevation or the emergency overflow weir elevation, whichever is higher, shall be placed within a common area either platted or legally described and recorded as a perpetual stormwater easement. A minimum of fifteen (15) feet horizontally from the top of bank of the facility, or the 100-

year pool if no defined top of bank is present, shall be dedicated as permanent stormwater easement if the above-noted boundary of the common area does not extend that far.

11. Detention basins shall be designed with an additional ten (10) percent of available capacity to allow for sediment accumulation resulting from development and to permit the pond to function for reasonable periods between cleanings. Basins should be designed to collect sediment and debris in specific locations, such as a forebay, so that removal costs are kept to a minimum. For wet-bottom ponds, the sediment allowance may be provided below the permanent pool elevation. No construction trash or debris shall be allowed to be placed within the permanent pool. If the pond is used as a sediment control measure during active construction, the performance and maintenance sureties will not be released until sediment has been cleaned out of the pond and elevations and grades have been reestablished as noted in the accepted plans.

03302.06 Additional Requirements for Wet-Bottom Facility Design

Where part of a detention facility will contain a permanent pool of water, all the items required for detention storage shall apply. Also, a controlled positive outlet will be required to maintain the design water level in the wet bottom facility and provide required detention storage above the design water level. However, the following additional conditions shall apply:

1. Facilities designed with permanent pools or containing permanent lakes shall have a water area of at least one-half (0.5) acre with a minimum depth of eight (8) feet. If fish are to be used to keep the pond clean, a minimum depth of approximately ten (10) feet shall be maintained over at least 25 percent of the pond area. The remaining pond area shall have no extensive shallow areas, except as required to install the safety ramp, safety ledge, and stormwater BMPs as required below. Construction trash or debris shall not be placed within the permanent pool. The pond design shall be according to the City of Westfield Public Works Department Standards and Specifications.

2. A safety ramp exit from the lake may be required in some cases and shall have a minimum width of twenty (20) feet and exit slope of 6 horizontal to 1 vertical (6:1). The safety ramp shall be constructed of suitable material to prevent structural instability due to vehicles or wave action.

3. Periodic maintenance is required in lakes to control weed and larval growth. The facility shall also be designed to provide for the easy removal of sediment that will accumulate during periods of reservoir operation. Maintenance shall be provided by restrictive covenants, policy or codes.

4. Methods to prevent pond stagnation, including but not limited to aeration facilities, should be considered on all wet-bottom ponds. Design calculations to substantiate the effectiveness of proposed aeration facilities, and any impacts on the effectiveness of the pond’s use as a stormwater BMP shall be submitted with final engineering plans. Agreements for the perpetual operation and maintenance of aeration facilities shall be included in the restrictive covenants of the development or as provided by policy or codes.

03302.07 Additional Requirements for Dry-Bottom Facility Design

In addition to general design requirements, detention facilities that will not contain a permanent pool of water shall comply with the following requirements:

1. Provisions shall be incorporated into facilities for complete interior drainage of dry bottom facilities, including a minimum 1% bottom slope in all directions if

tile underdrains (double wall smooth bore) are provided and a minimum of 2% if no underdrains are provided. A positive/gravity outlet is required for the underdrains in all dry-bottom detention facilities.

2. For residential developments, the maximum planned depth of stormwater stored shall not exceed four (4) feet.

3. In excavated detention facilities, a minimum side slope of 3:1 shall be provided for stability.

03302.08
Parking Lot Storage

Paved parking lots may be designed to provide temporary detention storage of stormwater on all or a portion of their surfaces. Depths of storage shall be limited to a maximum depth of six (6) inches. Ponding should, in general, be confined to those positions of the parking lots farthest from the area served. Before such detention method is allowed, a perpetual maintenance agreement must be executed by the owner or the developer and filed with the WPWD. In addition, the 100-year inundation boundary should be determined and clearly shown on the construction plans.

03302.09
Detention Facilities in Floodplains

Except for projects exempted under Chapter 03100, Section 03105-01, no detention facilities are allowed to be placed within floodplains of any regulated drain or watercourse that has more than 25 acres of contributing drainage area, whether designated as such on FEMA maps or not.

03302.10
Design of Detention Facility Emergency Spillways

Emergency overflow facilities such as a weir or spillway shall be provided for the release of exceptional storm runoff. The overflow facility shall be of such design that its operation is automatic and does not require manual attention.

Emergency overflow facilities shall be designed to convey, without overtopping the detention facility banks, one and one-quarter (1.25) times the peak inflow discharge resulting from the 100-year design storm event runoff from the entire contributing watershed draining to the detention/retention facility, assuming post-development condition on-site and existing condition off-site. The length of the weir is to be determined using the weir equation, with the overflow weir control elevation at the Pond's 100-year elevation (pond is assumed full to the overflow weir control elevation), discharge equal to 1.25 times the peak 100-year inflow, and the maximum head being the difference between the weir control elevation and the top of the bank.

The emergency overflow routing from the emergency overflow facility to an adequate receiving system must be by gravity and the spillway must be set at the highest elevation in the emergency flow routing. The emergency overflow routing and spillway, with a spot elevation labeled, must be shown on the construction plans and on the secondary plat. It must be sized to accommodate the design flow of the pond's emergency overflow weir. Thirty (30) feet along the centerline of this emergency overflow route shall be designated as permanent drainage easement. No fences or landscaping can be constructed within the easement areas. The Lowest Adjacent Grade of all residential, commercial, or industrial buildings along this emergency overflow route shall be set a minimum of 2 feet above the flood elevation along the route, calculated based on the pond's emergency overflow weir design discharge.

03302.11
Acceptable Outlet

Design and construction of the stormwater facility shall provide for the discharge of the stormwater runoff from off-site land areas as well as the stormwater from the area being developed (on-site land areas) to an acceptable outlet(s) (as determined by the WPWD) having capacity to receive upstream (off-site) and on-site drainage.

Outlets into regulated drains or natural watercourses shall provide a positive unobstructed or unrestrictive conveyance into said system. The following provisions shall be followed:

1. All conveyances shall terminate into an approved adequate outlet.

2. All outlets, either open drain or storm sewer, shall extend to the regulated drain or natural watercourse.

3. All storm sewer shall extend to either a receiving storm sewer system or an open regulated drain or natural surface watercourse as approved by the WPWD.

4. Storm sewers shall not outlet into rear yard swales.

5. Outlets shall not directly discharge onto the ground surface as surface flow.

6. Underwater discharges shall not be allowed. All discharges into a watercourse, pond, or lake shall have the invert at or above the normal pool elevation or normal flow elevation for the receiving stream.

The flow path from the development outfall(s) to a regulated drain or natural watercourse (as determined by the WPWD) shall be provided on an exhibit that includes topographic information. Any existing field tile encountered during the construction shall also be incorporated into the proposed stormwater drainage system or tied to an acceptable outlet. In addition, no activities conducted as part of the development shall be allowed to obstruct the free flow of flood waters from an upstream property.

Where the outfall from the stormwater drainage system of any development flows through real estate owned by others prior to reaching a regulated drain or watercourse, no acceptance shall be granted for such drainage system until all owners of real estate and/or tenants crossed by the outfall consent in writing to the use of their real estate through a recorded easement or are notified of such proposal and their rights to appeal any approval of the design. Proof of this notification must be submitted to the jurisdiction entity.

If an adequate outlet is not located on site, then further reduction in allowable release rates or off-site drainage improvements may be required. Those improvements may include, but are not limited to, extending storm sewers, clearing, dredging and/or removal of obstructions to open drains or natural water courses, and the removal or replacement of undersized culvert pipes as required by the WPWD.

Regulated Drain Considerations

If the project site's outlet directly discharges to a Hamilton County Regulated Drain, the applicant will also need to abide by the Hamilton County Surveyor's Office applicable requirements, whether the site is located in an incorporated area or not.

SECTION 03303 OPEN CHANNEL DESIGN

03303.01
Introduction

Open channel flow may be evaluated utilizing Manning's equation, however, restrictions within open channels, such as at open culverts or storm drains, may be required to be evaluated by more sophisticated design methods such as those listed in Section 03303.03.

03303.02
Mannings Equation

The waterway area for channels shall be determined using Manning's Equation, where:

$$A = Q/V$$

A = Waterway area of channel in square feet
Q = Discharge in cubic feet per second (cfs)
V = Steady-State channel velocity, as defined by Manning's Equation (See Section 03305.02)

03303.03
Backwater Method for Drainage System Analysis

The determination of 100-year water surface elevation along channels and swales shall be based on accepted methodology and computer programs designed for this purpose. Computer programs HEC-RAS, HEC-2, and ICPR are preferred programs for conducting such backwater analysis. The use of other computer models must be accepted in advance by the WPWD.

03303.04
Appurtenant Structures

The design of channels will include provisions for operation and maintenance and the proper functioning of all channels, laterals, travelways, and structures associated with the project. Recessed inlets and structures needed for entry of surface and subsurface flow into channels without significant erosion or degradation shall be included in the design of channel improvements. The design will also provide for necessary floodgates, water level control devices, and any other appurtenance structure affecting the functioning of the channels and the attainment of the purpose for which they are built.

The effects of channel improvements on existing culverts, bridges, buried cables, pipelines, and inlet structures for surface and subsurface drainage on the channel being improved and laterals thereto shall be evaluated to determine the need for modification or replacement. Culverts and bridges which are modified or added as part of channel improvement projects shall meet reasonable standards for the type of structure, and shall have a minimum capacity equal to the design discharge or governmental agency design requirements, whichever is greater.

03303.05
Grading and Depth of Open Channels

1. The required channel cross-section and grade are determined by the design capacity, the material in which the channel is to be constructed, and the requirements for maintenance. A minimum depth may be required to provide adequate outlets for subsurface drains, tributary ditches, or streams. The channel grade shall be such that the velocity in the channel is high enough to prevent siltation but low enough to prevent erosion. Velocities less than 2 feet per second are not acceptable, as siltation will take place and ultimately reduce the channel cross-section area. The maximum permissible velocities in

vegetated-lined channels are shown in Table 03303.01. In addition to existing runoff, the channel design should incorporate increased runoff due to the proposed development.

2. Where depth of design flow is slightly below critical depth, channels shall have freeboard adequate to cope with the effect of hydraulic jumps.

3. Along the streets and roads, the bottom of the ditch should be low enough to install adequately-sized driveway culverts without creating "speed bumps". The driveway culvert inverts shall be designed to adequately consider upstream and downstream culvert elevations.

4. Flow of a channel into a closed system is prohibited, unless runoff rate and head loss computations demonstrate the closed conduit to be capable of carrying the 100-year channel flow for developed conditions, either entirely or in combination with a defined overflow channel, with no reduction of velocity.

5. When the design discharge produces a depth greater than three (3) feet in the channel, appropriate safety precautions shall be added to the design criteria based on reasonably anticipated safety needs.

6. Swale side slopes shall be no steeper than 3 horizontal to 1 vertical (3:1). Flatter slopes may be required to prevent erosion and for ease of maintenance. The swale design shall be according to the City of Westfield Public Works Department Standards and Specifications.

7. Minimum swale slopes are 1.0%, unless designed to act as a stormwater quality BMP. All flow shall be confined to the specific easements associated with each rear and side lot swale that are part of the minor drainage system. Unless designed to act as a stormwater quality BMP, vegetated swales shall have tile underdrains to dry the swales. Tile lines may be outletted through a drop structure at the ends of the swale or through a standard tile outlet. Further guidance regarding this subject may be found in the latest edition of the Indiana Drainage Handbook.

8. Residential rear and side lot swales shall not exceed 300 feet in length to any inlet and shall not convey flow from more than 3 lots.

03303.06
Channel Stability

Characteristics of a stable channel are:

a] It neither promotes sedimentation nor degrades the channel bottom and sides.

b] The channel banks do not erode to the extent that the channel cross-section is changed appreciably.

c] Excessive sediment bars do not develop.

d] Excessive erosion does not occur around culverts, bridges, outfalls or elsewhere.

e] Gullies do not form or enlarge due to the entry of uncontrolled flow to the channel.

Channel stability shall be determined for an aged condition and the velocity shall be based on the design flow or the bankfull flow, whichever is greater, using an "n" value for various channel linings as shown in Table 03303.02. In no case is it necessary to check channel stability for discharges greater than that from a 100-year frequency storm.

Channel stability shall be checked for conditions representing the period immediately after construction. For this stability analysis, the velocity shall be calculated for the expected flow from a 10-year frequency storm on the watershed, or the bankfull flow, whichever is smaller, and the "n" value for the newly constructed channels in fine-grained soils and sands may be determined in accordance with the "National Engineering Handbook 5, Supplement B, Soil Conservation Service" (currently NRCS) and shall not exceed 0.025. This reference may be obtained by contacting the National Technical Information Service in Springfield, Illinois. The allowable velocity in the newly constructed channel may be increased by a maximum of 20 percent to reflect the effects of vegetation to be established under the following conditions:

a] The soil and site in which the channel is to be constructed are suitable for rapid establishment and support of erosion controlling vegetation.

b] Species of erosion controlling vegetation adapted to the area, and proven methods of establishment are shown.

c] The channel design includes detailed plans for establishment of vegetation on the channel side slopes.

Materials acceptable for use as channel lining are:

1. Grass (hand sown or hydroseed)
2. Revetment Riprap
3. Concrete
4. Hand Laid Riprap
5. Precast Cement Concrete Riprap
6. Gabions (or reno mattresses)
7. Coconut Mattings or erosion control blanket - only until grass is established

Use of bio-engineered (green solution) methods for lining materials is recommended and may be explored, as applicable. Other lining materials must be approved by the WPWD. Materials shall comply with the latest edition of the INDOT Standard Specifications.

03303.07
Drainage System
Overflow Design

Ponding and overflow path throughout the development resulting from a 100-year storm event or from a flood route of an internal detention pond or off-site development or watershed, calculated based on all contributing drainage areas, on-site and off-site, in their proposed or reasonably anticipated land use and with the storm pipe system assumed completely plugged, shall be determined, clearly shown as hatched area on the plans, and a minimum width of 30 feet along the centerline of the overflow path contained in permanent drainage easements. A continuous flood route from the sag inlets to the final outfall shall be shown and the minimum 30 feet along the centerline contained within an easement or road right-of-way regardless of the 100-year storm event ponding elevation. A statement shall be added to the secondary plat that would refer the viewer to the construction plans to see the entire extent of overflow path as hatched areas. No fences or landscaping or any other above grade improvements can be constructed within the easement areas that may impede the free flow of stormwater. These areas shall be designated as flood routes and contained in common areas that are to be maintained in accordance with restrictive covenants, codes or policies. The Lowest Adjacent Grade for all residential, commercial, or industrial buildings shall be set a minimum of 1 foot (rather than normal 2 feet, as the storm drains are assumed plugged as an additional safety factor) above the highest noted overflow path/ponding elevation across the property frontage.

All buildings shall have a minimum flood protection grade shown on the secondary plat. Minimum Flood Protection Grade of all structures fronting a pond or open ditch shall be no less than 2 feet (1 foot for the 100-year ponding/overflow paths as the storm drains are assumed plugged as an additional safety factor) above any adjacent 100-year local or regional flood elevations, whichever is greater, for all windows, doors, attached garage entrances, pipe entrances, window wells, and any other structure member where floodwaters can enter a building.

The overflow path/ponding may be modeled as successive series of natural ponds and open channel segments. Consideration shall be given to the highest ground elevations along the overflow path. Ponds should be modeled similar to that discussed for modeling depressional areas in Section 03302.02. Channels should be modeled according to modeling techniques discussed earlier in this Chapter. The calculations for determining the 100-year overflow path/ponding elevations may be based on hand calculation methods utilizing normal depth calculations and storage routing techniques or performed by computer models. Examples of computer models that either individually or in combination with other models can handle the required computations include TR-20, HEC-HMS, and HEC-1, combined with HEC-RAS. Other models may be acceptable and should be accepted by the WPWD prior to their utilization.

Values in Table 03303.03 may be utilized as an alternative to the above-noted detailed calculations for determining the required LAG or pad elevations of buildings near an overflow path.

If Table 03303.03 is used, WPWD reserves the right to require independent calculations to verify that the proposed building pads/building LAGs provide adequate freeboard above the anticipated overflow path/ponding elevations.

The LAG requirements for buildings adjacent to other flooding sources are discussed in Section 03105.02 of this Manual. In case there are more than one flooding sources applicable to a building site, the highest calculated LAG for the building shall govern the placement of the building on that site

In the case of existing upstream detention, an allowance equivalent to the reduction in flow rate provided may be made for upstream detention only when: (1) such detention and release rate have previously been accepted by the WPWD official charged with the approval authority at the time of the acceptance, and (2) evidence of its construction and maintenance can be shown.

SECTION 03304 CULVERTS/BRIDGES

03304.01 Introduction

The design methods and criteria outlined or referred to within this section shall be used in the design and evaluation of culvert systems within the jurisdiction of this Manual. Computer models such as Federal Highway Administration’s HY-8 may be used to perform culvert/bridge design computations.

Culverts/bridges under roadways, involving backwater and/or road overflow during the 100-year design storm, shall be analyzed utilizing the methodologies set forth in Section 03303.03 of this manual for determination of the depth of flow over the culvert/roadway during the peak discharge from the 100-year design storm event, backwater elevations, downstream flow velocities and resulting channel scour impacts.

In addition to satisfying any applicable state agencies' requirements, calculations should be provided showing the impacts of the proposed new or modified culvert/bridge (involving a raise of overflow elevation) for the 2-year through 500-year flood events on upstream elevations and downstream discharges. The design should also ensure that the minimum overflow section elevation (typically located on top of the bridge/culvert or on the approach road to accommodate passage of flood flows larger than the design flood) is not higher than the lowest adjacent grades of buildings located along the stream upstream of the crossing. The requirements of this paragraph also applies to other structures placed within the stream channels, such as fords, low-head dams, weirs, etc.

Additional design requirements for bridges and culverts are contained within Sections 02501 and 03201.03.

SECTION 03305 STORM DRAINS/INLETS

03305.01 Introduction

All storm sewers, whether private or public, and whether constructed on private or public property shall conform to the design standards and other requirements contained herein.

03305.02 Storm Drain Pipe Design

Determination of hydraulic capacity for storm sewers sized by the Rational Method analysis must be done using Manning's Equation where:

$$V = (1.486/n)(R^{2/3})(S^{1/2})$$

Then:

$$Q=(V)(A)$$

where:

Q = capacity in cubic feet per second
V = mean velocity of flow in feet per second
A = cross sectional area in square feet
R = hydraulic radius in feet
S = slope of the energy grade line in feet per foot
n = Manning's "n" or roughness coefficient

The hydraulic radius, R, is defined as the cross sectional area of flow divided by the wetted flow surface or wetted perimeter. Allowable "n" values and maximum permissible velocities for storm sewer materials are listed in Table 03303.02.

03305.03 Backwater Method for Pipe System Analysis

Various computer modeling programs such as HYDRA, ILLUDRAIN, and STORMCAD are available for analysis of storm drains. Computer models to be utilized, other than those listed, must be accepted by the WPWD. The use of submerged storm sewer outfalls is prohibited.

03305.04 Minimum Velocity

Minimum and maximum allowable slopes shall be those capable of producing velocities between 2.5 and 10 feet per second, respectively, when the sewer is flowing full. Maximum permissible velocities for various storm sewer materials are listed in Table 03305.01.

03305.05
Inlet Sizing and Spacing

Inlets or drainage structures shall be utilized to collect surface water through grated openings and convey it to storm sewers, channels, or culverts. The inlet grate opening provided shall be adequate to pass the design 10-year flow with 50% of the sag inlet areas clogged. An overload channel from sag inlets to the overflow channel or basin shall be provided at sag inlets. Inlet design and spacing may be done using the hydraulic equations by manufacturers or orifice/weir equations. Use of the U.S. Army Corps of Engineers HEC-12 computer program is also an acceptable method. Gutter spread on continuous grades may be determined using the Manning's equation, or by using Figure 03305.01.

The maximum inlet spacing shall be 400 feet.

Further guidance regarding gutter spread calculation may be found in the latest edition of HERPICC Stormwater Drainage Manual, available from the Local Technical Assistance Program (LTAP). At the time of printing of this document, contact information for LTAP was:

Indiana LTAP
Purdue University
Toll-Free: (800) 428-7369 (Indiana only)
Phone: (765) 494-2164
Fax: (765) 496-1176
Email: inltap@ecn.purdue.edu
Website: www.purdue.edu/INLTAP/

03305.06
Regulated Drain Pipe Size and Material Requirements

For storm sewer or subsurface drains that will become regulated drains, the following requirements shall be followed:

1. Storm sewers shall be reinforced concrete pipe with a minimum diameter of 12 inches.

2. Subsurface drains (SSD) shall be a minimum of 6 inches in depth and shall be double wall, smooth bore perforated plastic pipe.

SECTION 306 EASEMENTS

03306.01
Introduction

Guidelines for minimum easement widths are provided below. More stringent requirements for stormwater easement size and additional covenants may be made by the WPWD based upon individual size conditions.

Detention/retention basins shall be constructed within a common area either platted or legally described and recorded as a perpetual stormwater easement. A minimum of fifteen (15) feet horizontally from the top of bank of the facility shall be dedicated as permanent stormwater easement if the boundary of the above-noted common area does not extend that far.

Public street rights-of-ways will not be acceptable areas for construction of detention/retention facilities.

No drainage easement or a combination drainage and utility easement shall be located within a tree preservation easement.

03306.02 Easement Requirements

There shall be no trees or shrubs planted, nor any structures or fences erected, in any drainage easement, unless otherwise accepted by the WPWD. There shall be no trees within 10’ of any storm sewer including SSD.

A. All new channels, drain tiles equal to or greater than 12 inches in diameter, inlet and outlet structures of detention and retention ponds, and appurtenances thereto as required by this Article, that are installed in subdivisions requiring a stormwater management permit from the WPWD shall be contained within a minimum 20 feet of drainage easement (10 feet from centerline on each side) and shown on the recorded plat. New drain tiles refer to all sub-surface stormwater piping, tubing, tiles, manholes, inlets, catch basins, risers, etc.

B. A minimum of 25 feet from top of the bank on each side of a new channel shall be designated on the recorded plat as a Drainage Easement. If the top of bank is not vegetated according the development’s landscape plan, a minimum 25 foot width of filter strip shall be installed within the drainage easement.

C. Rear-yard swales and emergency overflow paths associated with detention ponds shall be contained within a minimum of 30 feet width (15 feet from centerline on each side) of drainage easement.

D. A minimum of 15 feet beyond the actual footprint (top of the bank or the 100-year pond elevation if no top of bank is present) of stormwater detention facilities shall be designated as drainage easement. A minimum 20 foot width easement shall also be required as access easement from a public right-of-way to the facility, unless the pond is immediately next to a public right-of-way.

E. The statutory 75-foot (each side) drainage easement for regulated drains already within the Hamilton County system may be reduced if the drain is re-classified by the County Surveyor as an Urban Drain.

F. Any outlet to, crossing, and/or encroachment of a Regulated Drainage Easement requires application and acceptance from the Hamilton County Surveyor’s Office.

SECTION 03307 WATERCOURSE IMPROVEMENTS

03307.01 Watercourse Improvement

Whenever a residential subdivision or commercial development constructs improvements upon lands, which is traversed by a watercourse, the landowner/developer shall make improvements to said watercourse at the discretion of the WPWD. These improvements shall consist of the following:

1. All debris and obstructions within the channel (bank to bank) shall be removed. This shall include but not be limited to logjams and trash.
2. Clear all trees which are dead and leaning at a 45 degree or greater angle or trees with roots that are exposed in the channel and potentially will fall into the stream. In clearing, the tree shall be cut flush with the ground and treated with an EPA-approved brush killer. For Hamilton County Regulated Drains, refer to the Standard Drawings OD-1, OD-2, or OD-3, as appropriate.

3. All stream bank erosion shall be repaired in an acceptable manner approved by the WPWD.
4. The above required improvements must be reflected on the overall design plans for the development and submitted to the WPWD for prior approval.

03307.01 Watercourse Maintenance

Entities owning property through which a watercourse passes, or such an Entity's lessee, shall keep and maintain that part of the watercourse in accordance any applicable City of Westfield ordinances. In addition, the Entity or lessee shall maintain existing privately owned structures within or adjacent to a watercourse, so that such structures will not become a hazard to the use, function, or physical integrity of the watercourse. The Entity or lessee shall not place or construct a privately owned structure(s) or other impairment within or adjacent to the watercourse such that it is an impairment or a detriment or in such a location that is in violation of City of Westfield ordinances.

Regulated Drain Considerations
If the water course is, or directly discharges to, a Hamilton County Regulated Drain, the applicant will also need to abide by the Hamilton County Surveyor's Office applicable requirements, whether the site is located in an incorporated area or not.

TABLE 03303.01

Maximum Permissible Velocities in Vegetal-Lined Channels (1)			
Cover	*Channel Slope Range (Percent)* **(3)**	*Permissible Velocity* **(2)**	
		Erosion Resistant Soils (ft. per sec.) **(4)**	*Easily Eroded Soils (ft. per sec.)* **(4)**
Bermuda Grass	0-5 5-10 Over 10	8 7 6	6 5 4
Bahia Buffalo Grass Kentucky Bluegrass Smooth Brome Blue Grama	0-5 5-10 Over 10	7 6 5	5 4 3
Grass Mixture Reed Canary Grass	**(3)** 0-5 5-10	5 4	4 3
Lespedeza Sericea Weeping Lovegrass Yellow Bluestem Redtop Alfalfa Red Fescue	**(4)** 0-5 5-10	3.4	2.5
Common Lespedeza **(5)** Sudangrass **(5)**	**(6)** 0-5	3.5	2.5

(1) From Natural resource Conservation Service, SCS-TP-61, "Handbook of Channel Design for Soil and Water Conservation".

(2) Use velocities exceeding 5 feet per second only where good channel ground covers and proper maintenance can be obtained.

(3) Do not use on slopes steeper than 10 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.

(4) Do not use on slopes steeper than 5 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.

(5) Annuals - use on mild slopes or as temporary protection until permanent covers are established.

(6) Use on slopes steeper than 5 percent is not recommended.

TABLE 03303.02

Typical Values of Manning's "n"		
Material	*Manning's "n"*	*Maximum Velocities (feet/second)*
◆ **Closed Conduits**		
Concrete	0.013	10
Vitrified Clay	0.013	10
HDPE	0.012	10
PVC	0.011	10
◆ **Circular CMP, Annular Corrugations, 2 2/3 x ½ inch**		
Unpaved	0.024	7
25% Paved	0.021	7
50% Paved	0.018	7
100% Paved	0.013	7
Concrete Culverts	0.013	10
HDPE or PVC	0.012	10
◆ **Open Channels**		
Concrete, Trowel Finish	0.013	10
Concrete, Broom Finish	0.015	10
Gunite	0.018	10
Riprap Placed	0.030	10
Riprap Dumped	0.035	10
Gabion	0.028	10
New Earth **(1)**	0.025	4
Existing Earth **(2)**	0.030	4
Dense Growth of Weeds	0.040	4
Dense Weeds and Brush	0.040	4
Swale with Grass	0.035	4

Source of manning "n" values: HERPICC Stormwater Drainage Manual, July 1995.

(1) New earth (uniform, sodded, clay soil)

(2) Existing earth (fairly uniform, with some weeds).

TABLE 03303.03

Minimum Building LAG Pad Elevations With Respect to Overflow Path Invert Elevations		
Drainage Area (acres)	**Minimum Building LAG, Pad, or Flood Protection Grade Above Overflow Path Invert (ft.)**	**Minimum Building LAG, Pad, or Flood Protection Grade Above Overflow Path Invert, if Overflow Path is in the Street (ft.)**
Up to 5	2.5	1.5
6-10	3.0	1.5
11-15	3.25	1.75
16-20	3.5	1.75
21-30	4.0	2.0
30-50	4.25	2.0

FIGURE 03305.01
Street and Gutter Capacities (continuous grade)